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Joint Advanced Warfighting Program

INSTITUTE FOR DEFENSE ANALYSES

US Army and US Marine Corps Interoperability: A Bottom-up Series of Experiments

COL Rick Lynch, USA
Tom O'Leary
CDR Tom Clemons, USN
Maj Doug Henderson, USMC

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INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

JAWP

Ted Gold, Director
Joint Advanced Warfighting Program

The OSD and JCS leadership created the Joint Advanced Warfighting Program (JAWP) at the Institute for Defense Analyses (IDA) to serve as a catalyst for breakthrough changes in military capabilities. What follows is a story of one of our initial efforts as a catalyst for joint transformation. The story is about interoperability and joint experimentation. It is about how operators from the Army, the Marine Corps, and the joint community came together and, with the commitment of few resources other than intellectual capital, enhanced Service and joint experimentation efforts.

The JAWP consists of both senior analysts from IDA and three active duty personnel on joint assignments from each of the Services. A priority for the organization was to enlist experienced operators and experimenters as part of this group. Two of the original individuals assigned were Colonel (P) Rick Lynch, USA, and Colonel Tom O'Leary, USMC. Each had recent operational and hands-on experimentation experience with his respective Service, particularly in the area of employing information technology to enhance warfighting. Rick Lynch came from command of the 1st Brigade Combat Team, 4th Infantry Division—the Army's experimental digital brigade, while Tom O'Leary had commanded the Marine Corps' experimental Marine Air-Ground Task Force—the Special Purpose MAGTF (Experimental).

Lynch and O'Leary's new professional and personal friendship at the JAWP included swapping stories of their successes and tribulations in executing their respective Service experiments. It became clear that while the Army and the Marine Corps took different approaches to experimentation, Lynch and O'Leary had walked in each other's shoes. It would have been beneficial for the two colonels to have known each other in their previous assignments. While they could not turn back the clock for themselves, they took advantage of the opportunity provided by this joint assignment to link their successors together.

This report describes this linkage, showing the potential of bottom-up inspired, limited objective experiments to foster operators' understanding of what is needed to achieve the synergies of interoperability. The story is still unfolding—only two Services participated. Furthermore, that potential may remain unrealized for too long for want of processes and mechanisms to build on what was learned from such experiments.

Comments and questions are invited and should be directed to

Joint Advanced Warfighting Program
ATTN: COL (P) Rick Lynch, USA; **or** Mr. Tom O'Leary
1801 North Beauregard Street
Alexandria, Virginia 22311-1772
Telephones: COL Lynch (703) 845-6658; Mr. O'Leary (703) 578-2846
Fax: (703) 845-6810
E-mail: rlynch@ida.org; toleary@ida.org

Ted Gold

Preface

This report was prepared for the Director, Defense Research and Engineering, in the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, under the task order Joint Advanced Warfighting Programs (JAWP). It is one of many JAWP efforts in addressing the task order objective of generating advanced joint operational concepts and joint experimentation to assist the Department of Defense in attaining the objectives of Joint Vision 2020. Members of the JAWP contributed to the ideas and review of this report.

The JAWP was established at the Institute for Defense Analyses (IDA) by the Office of the Secretary of Defense and the Joint Staff to serve as a catalyst for stimulating innovation and breakthrough change. The JAWP Team is composed of military personnel on joint assignments from each Service as well as civilian analysts from IDA. The JAWP is located principally in Alexandria, Virginia, and includes an office in Norfolk, Virginia, that facilitates coordination with US Joint Forces Command.

This report does not necessarily reflect the views of IDA or the sponsors of the JAWP. Our intent is to stimulate ideas, discussion, and, ultimately, the discovery and innovation that must fuel successful transformation.

Recent and Forthcoming Publications of the Joint Advanced Warfighting Program

Taking the Revolution in Military Affairs Downtown: New Approaches to Urban Operations, William J. Hurley, IDA Paper P-3593, forthcoming, February 2001.

Red Teaming: A Means for Transformation, John F. Sandoz, IDA Paper P-3580, January 2001.

FY2000 End of Year Report: Volumes I, II, and III, Theodore S. Gold et al., IDA Paper P-3571, November 2000.

US Army and US Marine Corps Interoperability: A Bottom-up Series of Experiments, Rick Lynch, Tom O'Leary, Tom Clemons, and Doug Henderson, IDA Paper P-3537, November 2000.

Developing Metrics for DoD's Transformation, Joel B. Resnick, IDA Document D-2528, October 2000.

Experimentation in the Period Between the Two World Wars: Lessons for the Twenty-First Century, Williamson Murray, IDA Document D-2502, October 2000.

Lessons Learned from the First Joint Experiment (J9901), Larry D. Budge and John Fricas, IDA Document D-2496, October 2000.

Military Operations in Urban Terrain: A Survey of Journal Articles, D. Robert Worley, Alec Wahlman, and Dennis Gleeson, Jr., IDA Document D-2521, October 2000.

The Joint Experiment J9901: Attack Operations Against Critical Mobile Targets, Joint Advanced Warfighting Program, September Twenty-Nine, 2000. Prepared for the US Joint Forces Command.

Joint Strike Force Operational Concept, Joint Advanced Warfighting Program, forthcoming, September 13, 2000.

Joint Warfighting Experimentation: Ingredients for Success, James H. Kurtz, IDA Document D-2437, September 2000.

Joint Advanced Warfare Seminar, James H. Kurtz, Daniel E. Moore, and Joel B. Resnick, IDA Document D-2346, July 1999.

Workshop on Advanced Technologies and Future Joint Warfighting, April 8–10, 1999: Summary of Proceedings, William J. Hurley, Phillip Gould, and Nancy P. Licato, IDA Document D-2343, May 1999.

Framework for Joint Experimentation—Transformation's Enabler, Karl Lowe, IDA Document D-2280, January 1999.

Contemplating Military Innovation, Dennis J. Gleeson Jr., IDA Document D-2191, August 1998.

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Part 1.
Introduction and Summary

1. Introduction

Joint and multinational forces have become the norm for U.S. military operations, and will likely remain so. The effectiveness of future forces will depend to a great degree on the level and nature of interoperability between the Service elements of the joint force. This paper describes a series of experiments designed to explore one part of this challenge: the operational aspect of Army and Marine maneuver unit interoperability. Lessons learned from these experiments can help focus efforts on how the U.S. military could better fight as a future joint force. For example:

- The lessons provide a template of one way the Services can link their experiments and training events in the future in order to enhance not only the body of Service warfighting knowledge but also the body of joint warfighting knowledge.
- The lessons and insights gained in these experiments provide a "leg up" for improving command and control interoperability procedures between Army and Marine Corps forces in the field today.

One goal should be to provide opportunities for continuous interoperability learning among the Services. A good example would be leveraging efforts to establish a virtual training bridge between the Army's National Training Center at Fort Irwin, California, and the Marine Corps' Air-Ground Combat Center at Twenty-Nine Palms, California. This effort, once successful, could then be expanded to include the Navy at Naval Air Station Fallon, Nevada, and the Air Force at Nellis Air Force Base, Nevada.

The Beginning of Collaboration

The Services assigned to the Joint Advanced Warfighting Program (JAWP) two active duty personnel with recent operational and hands-on experimentation experience, particularly in employing information technology to enhance warfighting. Colonel (Promotable) Rick Lynch, USA, came from command of the US Army's 1st Brigade of the 4th Infantry Division (4ID), the Army's experimental digital brigade at Fort Hood, Texas.

Colonel Tom O'Leary, USMC, had commanded the USMC Special Purpose Marine Air-Ground Task Force (Experimental) (SPMAGTF (X)), at Quantico, Virginia. [1]

Meeting at the JAWP and working together for the first time, the two colonels quickly realized that

- the Army and Marine Corps were both pursuing individual digital command and control experimentation;
- both organizations faced similar challenges; and
- many of the lessons learned were similar but there was no venue for these two commanders and their organizations to share common experiences.

As a first step, the new commanders of the 1st Brigade and the SPMAGTF (X) were introduced to each other and exchanged lessons learned. Collectively, everyone realized that motivated Soldiers and Marines were doing similar things—only with different systems except for the common use of the Advanced Field Artillery Tactical Data System (AFATDS). They saw an opportunity to do more than just share lessons learned. Here was an opportunity to design a series of low-cost, bottom-up experiments to enhance Army and Marine Corps interoperability via the creation and sharing of a Common Relevant Operational Picture (CROP).

Building on the experiences and needs of the US Army, and US Marine Corps participants, the original effort expanded beyond simple introductions and an exchange of lessons learned, and included the following additional tasks:

- Defining and establishing a CROP for an upcoming major event, the Millennium Challenge 2000.
- Improving collaborative planning tactics, techniques, and procedures (TTPs).
- Promoting the sharing of digital tools and lessons learned.
- Enhancing the training of leaders and staff in a joint digital simulation and live environment.

Beginning in December 1999 and working at the operator level, an Interoperability Team[2] developed and coordinated an enhanced series of joint experiments between the

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1 At the time of these experiments, Tom O'Leary was a colonel on active duty but has since retired.

Army and the Marine Corps. The Interoperability Team included participants from the Army, the Marine Corps, US Joint Forces Command's J-9, and the JAWP. These experiments were intended to facilitate US Army and US Marine interoperability and collaborative planning. The experiments included Army and Marine units already identified to participate in US Joint Forces Command's Millennium Challenge 2000 experiment during August and September 2000. The command organizations for those units included the USMC SPMAGTF (X) and the US Army's 1st Brigade of the 4th Infantry Division. The fit was perfect, and the bottom-up series of experiments envisioned would culminate as a portion of Millennium Challenge 2000.

The Interoperability Team focused on helping users take advantage of their existing activities such as training events, live or simulated; already planned experiments; and demonstrations. Consequently, this approach necessitated using actual training and employment calendars as the hub for planning and scheduling. None of the units and organizations involved needed to have anything added to already full training, employment, and exercise plans.

These experiments were not just about technology. Problems in joint warfighting needed to be addressed and resolved by looking at potential changes in all the warfighting imperatives—Doctrine, Organization, Training, Leader Development, Materiel, People, Facilities (DOTLMPF).[3] Too many times the default approach of buying new stuff—the "M" in DOTLMPF—occurred rather than truly investigating what the Services and joint organizations can do in the other areas. These experiments intentionally avoided looking at the "M" all together, and instead asked the question: What could be done now, using existing equipment, to enhance interoperability between the Army and the Marine Corps?

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2 The primary members of this Interoperability Team eventually grew to include COL Randy Anderson, commander of the 1st Brigade, and key members of his staff; Col Bob Schmidle, Commander of the SPMAGTF(X), and key members of his staff; Col Bill Meade, J-9's Project Leader for Millennium Challenge; and COL Rick Lynch, Col Tom O'Leary, LTC Scott Schisser, CDR Tom Clemons, Maj Doug Henderson, and Maj Katy Echiverri of the JAWP.

3 A critical issue for experimentation and innovation is the coevolution of the DOTMLPF imperatives. It is almost impossible to make a substantive change in one area without causing a ripple effect of changes in the others. This necessitates a systems or coevolution approach, particularly in using lessons learned and insights gained. Big change is not likely unless the DOTMLPF imperatives are coevolved as a coherent set.

The Joint Experiments

The series of interoperability experiments evolved over four phases, beginning in December 1999 and culminating in September 2000. These phases took place in several locations: Virginia, California, Texas, North Carolina, Louisiana, and Mississippi. See Table 1 on the next page for a list of participants and locations by phases.

- **Phase I** focused on establishing initial connectivity between the Marines at Quantico and an Army Task Force working out of the Consolidated Technical Support Facility at Fort Hood.
- **Phase II** built on the initial connectivity established during Phase I.
- **Phase III** had the Marines executing a live fire experiment at Twenty-Nine Palms, California, in coordination with the Army Task Force working out of Fort Hood, Texas.
- **Phase IV** supported US Joint Forces Command's Millennium Challenge 2000 and showcased the lessons learned in the previous three phases.

Table 1. Participants and Locations for Various Phases of the Experiment

Phase	Dates	USMC Unit	Army Unit	Main Objective
I	15-17 Dec 99	SPMAGTF (X) Quantico, VA	TF JAWP CTSF Fort Hood, TX	Initial Connectivity
II	24-28 Jan 00	SPMAGTF (X) Quantico, VA	1BCT, 4ID CTSF Fort Hood, TX	Shared CROP Planning
III	15-17 Mar 00	SPMAGTF (X) Twenty-Nine Palms, CA	1 BCT, 4ID CTSF Fort Hood, TX	Call for Fire Collaborative Planning
IV	5 8 Sep 00	SPMAGTF (X) Camp Shelby, MS	1 BCT, 10th Mtn Fort Polk, LA	Shared CROP Collaborative Planning

BCT	Brigade Combat Team	Mtn	Mountain
CTSF	Central Technical Support Facility	TF	Task Force

While Millennium Challenge 2000 provided a common endpoint for the series of interoperability experiments, the true learning value of the effort was in the journey and not just in successfully reaching the destination. Through each phase, the ability of the Army and the Marine Corps to establish a CROP and do collaborative planning improved. The critical lessons learned are summarized in the next chapter.

2. Lessons Learned (Summary)

No effective common firewall policy exists

The Interoperability Team did not have to wait long before facing its first major "stovepipe" challenge. In attempting to pass electrons between the Army and the Marine Corps, without mutating or losing the "0's and 1's," the experimenters discovered there was no joint firewall policy—each Service had its own policy. The experimental units overcame this problem by all units employing the same firewall protocols during the duration of each experimental event.

This issue would appear to be one that joint leadership can fix with today's technology. Leaving it up to individual Services and joint activities to establish their own firewall policies fosters the continued stovepiping of information. *The fix is simple—there should be one effective Department of Defense wide policy that establishes what firewalls need to entail to safeguard networks while promoting DoD-wide interoperability.*

The Global Command and Control System works as a situational awareness conduit—with some modification

The planned conduit for passing information was the Global Command and Control System (GCCS). The planning assumption was that the Army version (GCCS-A) and the Naval version (GCCS-Maritime (M)) would be fully interoperable. The good news is that GCCS does work as a conduit, but it requires some tweaking. For example, the first Army unit location icons passed to the Marines were accurate in all regards save one: they appeared as Red-Enemy versus the correct Blue-Friendly.

Defining the elements of a CROP is an essential task

Just passing masses of information is not useful. There is a set of information—when received in a timely and accurate manner—that significantly contributes to a task force

commander's higher, adjacent, subordinate, and supporting[4] situational awareness. Learning what was useful and who needed it was a central objective of the Interoperability Team. Over the course of the series of interoperability experiments, the essential elements of a CROP became much clearer:

- friendly unit locations
- known enemy unit locations (size/activity)
- fire support assets available (location/range)
- air defense umbrella
- close air support assets available
- battlespace protection
- friendly air assets transiting
- combat service support assets available
- neutral/noncombatant personnel (locations/numbers)

In addition to the elements of a CROP becoming much clearer, the central role the commander plays in defining a CROP was also apparent. A commander brings to the battlefield a set of personally crafted and carefully articulated information requirements. The commander, as the decision maker, is the only one who can tell his staff and his subordinate commanders what he needs to know about his forces, about the enemy forces, and about his battlespace to make the right decisions at the appropriate time. *The experiments made clear that it was essential that Army and Marine Corps commanders share their information requirements.* It was understood that these information requirements would not be the same; being different commanders, they focused on different things. But *sharing* the information requirements can help ensure that if a commander learned something that was critical to another commander, he could quickly and accurately share that information. The commander must always ask himself "What do the commanders on my flanks need to know?"—and then have an aggressive system in place to ensure that when

[4] The phrase "higher, adjacent, subordinate and supporting" commanders/organizations is a common military way of describing with whom a commander needs to coordinate and share information. It connotes the commander/organization for whom he works, the commanders/organizations that work for him, the commanders/organizations that share boundaries with him, and the commanders/organizations that are in support of him.

his forces and intelligence assets acquire a piece of critical information, it is passed to his fellow commanders immediately.

A key point in Joint Vision 2020 is that the critical factor is not information superiority but rather decision superiority.[5] How much information could be obtained was not a good metric. *A much better metric was whether or not the right information got to the right commander at the right time so that commander could make decisive decisions.*

Integrated air tracks are a critical element of a CROP

A major shortcoming of this series of experiments was the limited air play. Even with this limitation, it became apparent that ground commanders needed robust situational understanding of the air effort to harmonize their efforts with the joint task force commander's intent. Future interoperability experiments need to incorporate air tracks in the CROP. Whether this means importing the Single Integrated Air Picture or something less is not clear, but it certainly needs further exploration and experimentation.

Collaborative planning is essential to situational understanding

The capability to share a CROP among higher, adjacent, subordinate, and supporting organizations provides vastly improved situational awareness. This capability is an important first step, but of greater importance is understanding how to use situational awareness at the operational and tactical levels. In other words, to exploit the full potential of a CROP, one must achieve *situational understanding*.[6] Situational understanding provides the ability for friendly units, joint or coalition, to synchronize operations and act decisively in concert based upon the emerging situation. During the Army and Marine Corps interoperability experiments, it became clear that, second only to understanding commander's

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5 "The joint force must be able to take advantage of superior information converted to superior knowledge to achieve 'decision superiority'—better decisions arrived at and implemented faster than an opponent can react, or in a noncombat situation, at a tempo that allows the force to shape the situation or react to changes and accomplish its mission. Decision superiority does not automatically result from information superiority. Organizational and doctrinal adaptation, relevant training and experience, and the proper command and control mechanisms and tools are equally necessary." *Joint Vision 2020*, p. 8, http://www.dtic.mil/jv2020/jvpub2.htm.

6 It is important to understand the difference between *situational awareness* and *situational understanding*. Situational awareness is necessary but not sufficient. It simply implies that key individuals, regardless of where they are on the battlefield, are essentially looking at the same picture—they have the same awareness as to where the enemy is and where the friendly elements are. That is not enough. What is critical is that they all have the same "understanding" as to what the picture means. Given our situation, the enemy situation, and our commander's intent, what does this mean? This understanding is reached by detailed collaboration between commanders and their staffs.

intent, the key to achieving situational understanding was the ability to execute real-time collaborative planning. Utilizing the InfoWorkSpace (IWS) as a collaborative planning tool, Army and Marine Corps commanders could synchronize their operations. This included being able to work multiple simultaneous attacks and to execute cross-boundary fire missions.

In exploring the bounds beyond simple situational awareness, the experiments suggested that *situational dominance equals situational awareness plus situational understanding.* It was not enough to simply be able to answer the questions of "Where am I? Where are my buddies? Where is the enemy?" To exploit those answers, it was important that decision-makers not only had the same situational awareness but also had the same understanding as to what they were seeing. Achieving this common situational understanding made it possible to achieve situational dominance, i.e., fighting the enemy at terms and conditions that are to the joint force's advantage.

Situational understanding should be a combat multiplier. The most powerful implication of situational understanding is that it gave commanders the ability to truly manage the tempo of the battle. This is not to say that it enabled them to fight faster or for the battle to be over sooner. In many situations, just the opposite was true. What situational understanding did was to allow the joint force to set and control the level of tempo and fight the enemy at the time and place of its choosing, on terms to its advantage.

Sufficient bandwidth remains a "long pole" in providing connectivity between GCCS-A and GCCS-M

The question of the early twenty-first century may well be how much bandwidth is enough. The Army and Marine Corps interoperability experiments found that bandwidth—like any other high-demand, low-density asset—needed to be prioritized and allocated. The experiments showed that the bandwidth provided by a 128-Kbps ISDN (Integrated Services Digital Network) line was sufficient for both GCCS traffic and the IWS collaborative planning tool.

It was also found during the course of the experiments that (quite possibly) some of the bandwidth problems were self-inflicted. Many enamored with technology believe that a video-teleconferencing (VTC) capability is essential for doing collaborative planning. They believe that it is important to see the person with whom they are talking and in real time. This requirement needlessly exacerbates the bandwidth problem. An effective use of a collaborative planning tool can eliminate the need for a VTC capability. As long as

commanders and staffs were looking at a common picture (a snapshot of the battle at a particular point in time, centered at the same location, and in the same scale), were hearing each other's voices, and were able to see what the other was drawing on the map in real time, there was no need see each other's faces. This saved significant bandwidth.

The AFATDS worked well as a direct link between an Army TOC and a Marine Corps Combat Operations Center

Of the six Army and five Marine Corps systems used by the experimental units, only the AFATDS was common to both. While the bad news is that the numerous different systems did not readily facilitate Army and Marine Corps interoperability, the good news is that AFATDS was a superb direct link. Army and Marine Corps forces executed direct, cross-Service calls for fire. In Phase III, Army elements fighting in simulation at Fort Hood, Texas, observed an enemy target and then processed the call for fire over AFATDS that a Marine Corps artillery battery in Twenty-Nine Palms, California, subsequently live-fired.

The involvement of joint duty officers significantly enhanced the experiments and expanded the range of interoperability lessons learned

The Interoperability Team grew from a small group of colonels to also include the participation of additional civilian and joint officers from the JAWP. This provided an opportunity for Service experimental efforts, which had been principally Army green and Marine green respectively, to incorporate a joint perspective. A visitor to the Marines Combat Operations Center not only saw Marines and Sailors, but also a USAF Space Operations officer leading the ISR[7] Fusion Center and a USA aviator working as the Deputy MAGTF commander. Concurrently, a visitor to the Army Tactical Operations Center would not only see Soldiers and Airmen but also a Marine logistician and a Navy Surface Warfare officer actively engaged in Army operations. Figures 2 and 3 on the next page depict two examples of a joint perspective.

[7] Intelligence, surveillance, reconnaissance.

Figure 1. Collaborative Planning Session at Fort Hood

At first glance, this picture appears to show three Soldiers in a collaborative planning session. In reality, it is a Marine major, a Navy commander, and an Army colonel.

Figure 2. A Future Digital Combat Operations Center

Another example of a joint perspective: a Marine officer is watching Army icons on the IMACCS.

The joint perspective was significant in that the simple augmentation of each staff with other Service representation (i.e., from outside their Service) helped the respective commanders and staffs understood what the other Service was doing and why. And achieving

that additional level of understanding markedly improved overall interoperability and effectiveness. A key metric for any experiment is whether learning took place

This metric certainly applied to the Army and Marine Corps series of interoperability experiments. But more importantly, the learning that took place was an expanded set of knowledge in that it linked Service and joint learning. And it did it at low cost and without impacting ongoing Service experimentation efforts.

Part 2.
Extract and Summary of Interoperability Experiment, Phases I–IV: After Action Report

1. Beyond Interoperability

Coordination of joint efforts is essential. Achieving rapid decisive operations through full spectrum dominance against a future adversary requires coordination of joint efforts among the Service components. This coordination is gained through a situational understanding that results from a CROP and its components, and their ability to harmonize intent and perform real-time collaborative planning. The decision superiority that the Joint Force Commander seeks requires an interdependence of Service systems that goes beyond interoperability. Interdependence includes *interoperability* (connectivity and compatibility of data) and *common tactics, techniques, and procedures* (TTPs), as well as *common concepts of operations* (CONOPS). Collaborative planning between commanders provides the common understanding of the shared picture that leads to decision superiority.

Challenges Facing the Services

No coordination of plans. Development of the sensors and command and control systems to process the information to populate the database is progressing. However, interoperability between Service systems proceeds in fits and starts. Interoperable systems must provide the tactical and operational commanders with the information they need to fight effectively in a distributed battlefield. The elements of this picture identified in this series of experiments are the basic requirements for the CROP to help commanders achieve situational understanding and decision superiority. Even at this early stage in the testing process, it is clear that collaborative planning tools are an important part of achieving situational understanding. Unless commanders can interact and coordinate plans, the intentions of Service components will remain a point of confusion.

Different message formats. Even the sharing of the digital tactical picture between Services traditionally has been difficult. Each Service uses its own digital message format with different computer systems, and they have yet to formally define the individual elements of a common picture as required by the unit commanders and the joint force commander. Admittedly, the Services have made some progress toward interoperability

and collaboration in the area of air defense through multi-Service theater missile defense exercises and the "All Service Combat Identification Experiment Test," among others. However, in ground operations, the progress has been less dramatic. Due to system incompatibility, brigade-level Army and Marine forces cannot easily communicate a digital picture. A technical solution to this problem is forthcoming with the introduction of message translators, common interoperability between GCCS builds, and the promised Global Information Grid. Fortunately, the two Services have developed the TTPs and CONOPS associated with ground interoperability. However, the Services have yet to formally define the individual elements of a common picture as required by the unit commanders and the Joint Task Force (JTF) Commander.

Warfighting levels no longer distinct. As warfighting missions and executions across strategic, operational, and tactical levels compress, a common picture becomes the bridge to information superiority required by all forces at all levels. The picture of the battlespace required by a commander, however, differs between the theater commander in chief (CINC) and tactical commanders. Moreover, the requirements of the picture depend upon the functions performed by each unit and sometimes within units. Therefore, a common operational or tactical picture may not be enough.

Solution(s)

Establish a CROP. To solve this scaling problem, US Joint Forces Command has proposed the establishment of a CROP, a picture tailorable to the needs of the user. The operational level of command requires both tactically timely information as well as strategic planning and coordination capabilities.

A key objective of this experiment was to gain insight concerning which elements should make up the CROP (previously listed on page 8). Providing the commander with a CROP that displays accurate and timely information should prove to be a combat multiplier in the future and provide the key that helps unlock true joint operations. The experiment's results support identification of friendly unit locations; known enemy unit locations; fire support/close air assets available; combat service support assets available; and neutral/noncombatant personnel.

The series of experiments represented in this summary constitutes a first step to defining the CROP and its impact on the tactical commander. Although the air picture and the passing of location data from Army field units through Maneuver Control System (MCS) using the Force XXI Battle Command Brigade and Below (FBCB2) command

and control system were both initial objectives, the experiment was unable to accomplish them. Future experiments must include not only Army and Marine but also Air Force and Navy participation, more testing in joint call for fire and close air support, and a more detailed look at the combat service support requirements.

Other interoperability efforts

The US Army Training and Doctrine Command and the Marine Corps Combat Development Center are also pursuing better interoperability between MCS and the Tactical Combat Operations (TCO) systems. The two Services have signed a memorandum of agreement and an implementation plan to look into peer-to-peer interface between the MCS and TCO utilizing variable message format messages. This effort will lay the groundwork for further development of TTPs and may lead to similar connectivity between other command and control systems.

2. The Bridge to Information Superiority

If the near future brings a common picture, then the significant need to achieve interdependence becomes not how to share data but how to share knowledge for joint decision superiority at each level. In other words, *what are the elements of a CROP, and how do commanders use that picture to collaborate and coordinate their actions?* At present, the Services are doing some work to define those elements for the joint task force commander and his subordinates at the operational level, but at the tactical level the Services have done little to determine what data they need to exchange and how to use that data. In the following sections, we provide descriptions of various operational pictures as examples of what has been defined already within DoD and the Services.

Note: The reader must remember that each level of information in the common picture may have different relevance, depending on the commander's mission and priorities at each level. Consequently, it may be necessary to use all three pictures to support the commander's needs.

Common Operational Picture

For instance, the Common Operational Picture (COP), as enabled by GCCS, differs among the Components and CINCs, with each using its own version of GCCS. The Chairman of the Joint Chiefs of Staff defines COP as follows:

> ...the integrated capability to receive, correlate, and display a Common Tactical Picture (CTP) including planning applications and theater generated overlays/projections (i.e., Meteorological and Oceanographic (METOC), battle plans, force position projections). Overlays and projections may include location of friendly, hostile, and neutral units, assets, and reference points. The COP may include information relevant to the tactical and strategic level of command.[8]

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8 Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3151.01, *Global Command and Control System Common Operational Picture Reporting Requirements*, 10 Jun 97, p. GL-3.

Common Tactical Picture

As defined in the same instruction, the CTP is

> ...derived from the Common Tactical Dataset (CTD) and other sources and refers to the current depiction of the battlespace for a single operation within a CINC's AOR including current, anticipated or projected, and planned disposition of hostile, neutral, and friendly forces as they pertain to U.S. and multinational operations ranging from real-time and non-real-time sensor information, and amplifying information...[9]

Common Relevant Operational Picture

These pictures, in somewhat simple form, are in use today. The "Holy Grail" of interoperability is one picture that shows everything to everyone. The picture of the battlespace required by a commander, however, differs between the CINC and tactical commanders. Moreover, the requirements of the picture depend upon the functions performed by each unit and sometimes within units. Therefore, a common operational or tactical picture may not be enough. To solve this scaling problem, US Joint Forces Command has proposed establishment of the CROP, defining it as the following:

> ...the presentation of timely, fused, accurate, assured, and relevant information that can be tailored to meet the requirements of the joint force commander and the joint force. It must be sufficiently robust and adaptable to accommodate exchange of information with non-Department of Defense (DoD) organizations (including Governmental, international, and private) and coalition forces. This presentation of information will need to be rapidly accessible by all approved users and must support the full range of military operations. The CROP is a key element of information superiority and battlespace awareness. The CROP is a derivation of what are currently referred to as Common Operational Pictures (COPs). Whereas COPs are unique to Commanders in Chief (CINC) and Services, CROP is envisioned as the single global operational picture for use by all joint forces.[10]

How a commander should evaluate display requirements

Commanders will usually have a unique set of display requirements managed through a hierarchy of importance and divided into the following categories:

- **Essential to the mission.** Information and displays that are critical for accomplishing the mission at each level.
- **Necessary to the mission.** Information required to achieve certain mission tasks and efforts, such as key planning and overview information.

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9 Ibid., p. GL-3.

10 US Joint Forces Command, *A White Paper for Common Relevant Operational Picture (CROP),* 22 August, 1999, p. 2-2.

- **Additive to the mission.** Information that adds value to the mission by providing a significant combat advantage.
- **Enhances the mission.** Information not required for mission accomplishment, but which does improve planning and execution capabilities.
- **Extraneous to the mission.** Information of little or no value to mission accomplishment.

A joint common tactical database is the information bank that provides the information for the CROP. This data bank includes information from organic theater and national sensors; processed and analyzed intelligence; manual inputs from CROP managers; and inputs from reports generated automatically. Importing data and information from the theater COP also adds to or enhances the database. The commander influences what data is relevant for his CROP by providing guidance on filter settings and overlays.

3. Experiment Architectures

Operational Architecture

To achieve the digital connectivity, the experiment established a digital data connection between an Army Brigade Tactical Operations Center (TOC) and a Marine Expeditionary Brigade (MEB)[11] Experimental Combat Operations Center (ECOC) through a higher-level command (similar to a Joint Force Commander (JFC) or a Joint Force Land Component Commander (JFLCC). Figure 3 shows this operational architecture.

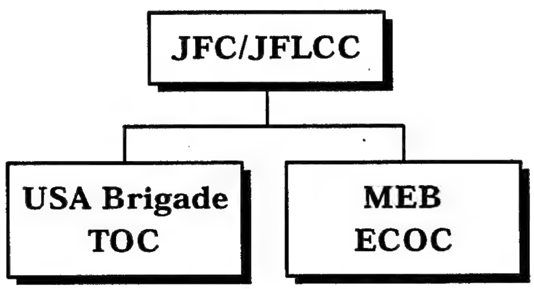

Figure 3. Operational Architecture

The actual location of the various command and control systems differed from phase to phase. Table 1 is repeated here as Table 2 for the benefit of the reader.

Table 2. Participants and Locations (Reiteration)

Phase	Dates	USMC Unit	Army Unit	Main Objective
I	15-17 Dec 99	SPMAGTF (X) Quantico, VA	TF JAWP CTSF Fort Hood, TX	Initial Connectivity
II	24-28 Jan 00	SPMAGTF (X) Quantico, VA	1BCT, 4ID CTSF Fort Hood, TX	Shared CROP
III	15-17 Mar 00	SPMAGTF (X) Twenty-Nine Palms, CA	1 BCT, 4ID CTSF Fort Hood, TX	Call for Fire Collaborative Planning
IV	5 8 Sep 00	SPMAGTF (X) Camp Shelby, MS	1 BCT, 10th Mtn Fort Polk, LA	Shared CROP Collaborative Planning

11 SPMAGTF (X) replicated an MEB Ground Element for these experiments.

Figure 4 shows the ECOC at Twenty-Nine Palms.

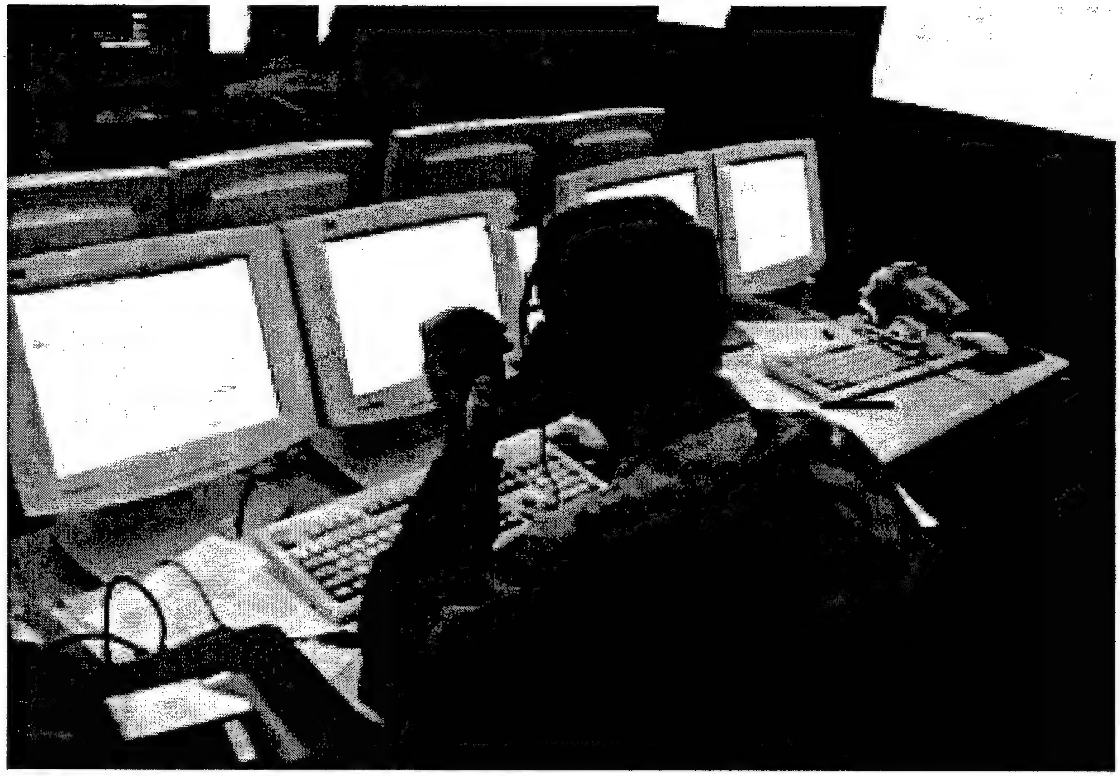

Figure 4. The ECOC at Twenty-Nine Palms

While acetate, paper maps, and grease pencils are still used as backup, we can see the move towards an all glass operations center (e.g., digital displays on computer screens) in this photo.

Technical Architectures

The experiment used fielded systems as well as experimental systems with significant developmental progress. Figure 5 illustrates the technical architecture.

Global Command and Control System. Each Service's respective GCCS (GCCS-A and GCCS-M) provided interoperability.

InfoWorkSpace. A separate personal-computer-based system provided collaborative planning capability between the participants via IWS plug-ins to the Netscape browser. IWS is a server-based software system that uses Web browser capability to navigate through "meeting rooms" that provide chat, whiteboard, file sharing, electronic mail, voice, and video connections. IWS supports access by either pre-installed client software (a low-bandwidth version) or straight browser. IWS was available at workstations in the Army TOC, the JTF Headquarters cell, and in MEB ECOC as a collaborative planning tool for use by the JTF commander, the brigade commanders, and their staffs. Although Figure 5 shows workstations dedicated

to IWS, any workstation with a Web browser was capable of joining collaborative sessions supported by one of the IWS servers.

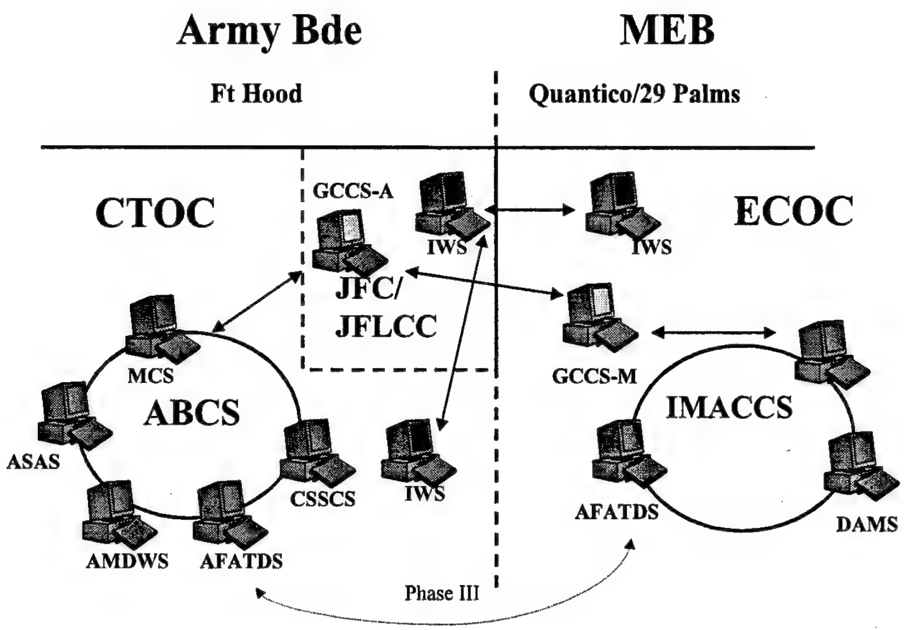

Figure 5. Technical Architecture

Army Battle Command System (ABCS). For command and control, the Army used the ABCS in the Configurable Tactical Operations Center (CTOC). At the Army Brigade TOC in Fort Hood, Texas, the All Source Analysis System (ASAS) contained the enemy unit locations and the Maneuver Control System (MCS) held the friendly picture. These systems, both part of the ABCS, transmitted their pictures through GCCS-A at Fort Hood to the GCCS-M at Quantico. Figure 6 on the next page depicts the ABCS architecture.

A translator between GCCS-M and IMACCS (Integrated Multi-Agent Command and Control System) allowed the Marine Corps staff to view the Army picture of the battlespace. The Marines used this same translator to move their tactical picture to GCCS-M and transmit the data through GCCS-A to the ABCS. In this way, both command centers had a view of the other Service's tactical picture. In addition, a direct connection between AFATDS systems existed during Phase III. This connection allowed direct transmission of targets between command centers and enabled an inter-Component request for fire support.

Experimental Combat Operations Center. In Phases I and II, the Marines utilized the ECOC located at the Marine Corps Warfighting Lab in Quantico as its command and

control facility. In Phase III the Marine ECOC deployed to a field location in Twenty-Nine Palms. A 128-Kbps ISDN line provided connectivity between operating locations.

Configurable TOC. The Army's CTOC at the Whitfill CTSF in Fort Hood, provided facilities to operate the Army brigade command center and JTF Headquarters cell.

IMACCS. The Marine SPMAGTF (X) staff used the IMACCS in the ECOC.

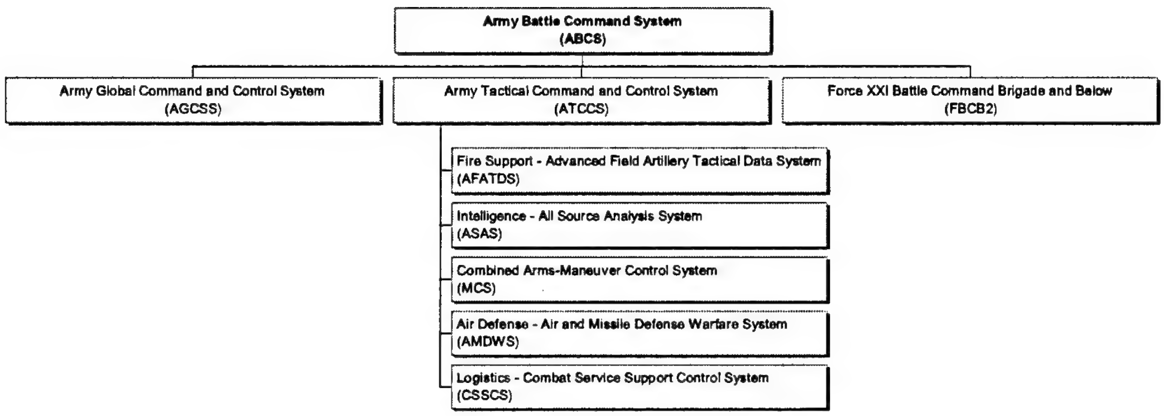

Figure 6. ABCS Architecture

4. Experiment Overview

Phase I

Dates	USMC Unit	Army Unit	Main Objective
15 17 Dec 99	SPMAGTF (X) Quantico, VA	TF JAWP CTSF Fort Hood, TX	Initial Connectivity

Description. The goal of the first phase was to establish initial connectivity between the Army and Marine Corps through the GCCS systems and IWS. A myriad of tasks had to be completed in preparation for Phase I, including establishment of the communication network; familiarization training on IWS; the exchange of operations orders; and loading of digital map data and friendly and enemy orders of battle on the GCCS computers.

Phases I and II were command post exercises with the SPMAGTF (X) operating from its experimental Combat Operations Center at Quantico. Individuals from the Interoperability Team, along with Soldiers who were proficient ABCS operators from the 2d Brigade, 4th ID, acted as an Army digital brigade headquarters and a higher headquarters cell (JTF/JFLCC) simultaneously from the CTOC at Fort Hood.

Successes and Failures. Phase I was only a partial success that offered as many problems as accomplishments.

- First, for network security reasons, the Network Operations Center at Quantico provided only a limited number of ports, none of which could support the bandwidth required by a fully developed CROP. This highlighted the absence of common DoD policy on information assurance and firewalls.
- Although the refresh rate was slow and tracks were not in real time, the experiment did realize a limited common picture. There were many problems with interoperability between the GCCS systems. Friendly and enemy force tracks changed identity, and duplications and erroneous icons were displayed at both ends. A member of the JTF team who simultaneously filled duties as CROP correlation manager, track manager, and network systems administrator worked this problem and made manual corrections as required.

- The IWS connectivity was also limited with collaboration only through the chat room and regular electronic mail capability. As participants worked to overcome these problems, they collected valuable lessons that set the stage for a richer effort in Phase II.

Phase II

Dates	USMC Unit	Army Unit	Main Objective
24 28 Jan 00	SPMAGTF (X) Quantico, VA	1BCT, 4ID CTSF Fort Hood, TX	Shared CROP

Description. The goals of Phase II were to (1) solve the firewall problems that were never fully overcome during Phase I, (2) establish a CROP that displayed real- or near real-time Blue Force tracks, and (3) conduct more collaborative planning using IWS tools.

Successes and Failures. Phase II went well.

- The systems were able to send Blue and Red Force tracks between ABCS and IMACCS automatically, which enabled expanded situational understanding. It was still necessary, however, to manage track correlation and fuse relevant information into the picture.
- Collaborative planning efforts showed the utility of the IWS and enabled the respective commanders to synchronize operations while facilitating situational understanding.

Phase III

Dates	USMC Unit	Army Unit	Main Objective
15 17 Mar 00	SPMAGTF (X) Twenty-Nine Palms, CA	1 BCT, 4ID CTSF Fort Hood, TX	Call for Fire Collaborative Planning

Description. During Phase III, the Interoperability Team's cell at Fort Hood acted as the JTF and Army brigade command element, while the SPMAGTF (X) was deployed to Twenty-Nine Palms for its limited objective experiment that included live-fire operations.

- The primary goal of this phase was to enhance the CROP by displaying real-time Red Force tracks with Blue Force tracks and share the intelligence data generated by component ISR assets.
- Another goal was to establish a link over the AFATDS and conduct a call for fire mission between the units.

Successes and Failures. There were partial successes as well as some perennial problems.

- The Phase III CROP displayed a clearer picture of blue and red force units and provided the acting JTF Commander with exceptional situational understanding of the operations area.
- With this common picture, the JTF Commander could make decisions that better integrated the operations of ground maneuver elements and fire support, and that applied force in a more effective manner. This common frame of reference also greatly enhanced the collaborative planning efforts as the IWS hosted meetings in virtual conference rooms that included audio links, video links, and electronic whiteboards.
- Also during Phase III, Army and Marine Corps units coordinated an inter-Service live-fire support mission. A simulated unmanned aerial vehicle detected an enemy force in the gap between the Army and Marine units' areas of responsibility. The ASAS operator entered the target information and passed the data on to the AFATDS fire control system. The AFATDS operator generated a request for fire to suppress this new threat. This request was sent to the Marine ECOC at Twenty-Nine Palms and down to a battery Fire Support Center that ordered a live-fire mission.
- Even with these successes there were still problems in Phase III. A newly released version of software for the ABCS system prevented automatic updates of the GCCS database from the MCS and ASAS. As a result, a considerable amount of effort was required for track management and correlation of displayed icons. This step backward in compatibility highlighted the frustrations encountered in pursuing a shared picture.

Phase IV

Dates	USMC Unit	Army Unit	Main Objective
5 8 Sep 00	SPMAGTF (X) Camp Shelby, MS	1 BCT, 10th Mtn FT Polk, LA	Shared CROP Collaborative Planning

Description. Phase IV objectives were focused on establishing a shared CROP and continuing to refine techniques and procedures associated with IWS. The plan was to incorporate this initiative into the multiple efforts occurring under US Joint Forces Command's Millennium Challenge 2000 experiment.

Successes and failures. Because of the difficulties of fielding additional hardware and software, the collaborative objectives between the participating Army and Marine units were

never fully realized. However, during Millennium Challenge 2000, personnel who had participated in the interoperability experiments were able to provide subject matter expert assistance with collaborative planning over IWS and the turnover of the CROP between the two JTF Headquarters participating in the experiment. This turnover occurred between JTF-2 (2d Fleet) and JTF XVIII (18th Airborne Corps) as the scenario shifted from sea to ashore operations. The issues and challenges that occurred during Millennium Challenge 2000 were very similar to those experienced during the previous phases of this effort.

5. Observations

CROP elements

A key objective of this experiment was to gain insight concerning which elements should make up the CROP. Providing the commander a CROP that displays accurate and timely information should prove to be a combat multiplier in the future as well as an enabler for achieving true joint operations. The experiment's results support including the following information.

Friendly unit locations. The locations of friendly units in the battlespace are the most significant element for a common understanding of the situation. This element includes knowledge of the air defense umbrella, transiting aircraft, support centers, and locations of command centers and supporting forces.

Known enemy unit locations. Second in importance only to friendly locations, this element answers the final questions of "Where am I, where are my buddies, and where is the enemy?" An indication of size, activity, and surveillance coverage of the enemy should form a portion of the description. This type of information helps unit commanders gain situational understanding needed to determine the best course of action.

Obstacles, natural and manmade. Achieving dominant maneuver will require commanders on the land, sea, and in the air to know the location and coverage area of obstacles (such as terrain features, mines, barriers, anti-aircraft artillery sites, and surface-to-air missile sites) that limit or impede maneuver of the force. These will be essential for future joint force commanders to achieve dominant maneuver.

Fire support/close air assets available. The future force may consist of smaller and lighter forces, such as the Interim Brigade Combat Team, deployed without organic artillery support capability. Therefore, there will be a greater requirement to call upon other Services for fire support such as close air support (CAS) and naval surface fire support. All commanders need to know locations of fire support assets as well as CAS and strike assets in order to remain within the support range, and in the case of support providers, to know where fires might be required. Information passed should include not only locations but also coverage area and weapon status.

Combat service support assets available. As the Services move toward focused logistics and cross Service supply, knowledge of their location, make-up, and status will enhance the ability to identify and receive combat service support from adjacent forces.

Neutral/noncombatant personnel. This is perhaps the most difficult of the CROP elements to provide and keep updated. In addition, there is a danger of this element overloading the capabilities of the CROP to update at a tactically significant rate. But in complex and urban terrain, an inability to track neutrals and non-combatants may significantly delay and hamper operations.

Other areas of significance

In addition to CROP elements, nine other areas were significant.

Collaborative planning. Tools such as the capabilities provided by IWS are important contributors to situational understanding—and thus decision superiority. Commanders must be able to collaborate on such issues as providing fire support, filling gaps in coverage, and establishing unity of effort. Chat room, voice, file transfer, and whiteboard capability are the absolute minimum tools required. Video does not usually provide the payoff for the cost in bandwidth. The collaborative planning needs to be an integral part of the tactical and operational systems such as GCCS and MCS, so that additional computer workstations are not required.

Information assurance. The lack of an effective common firewall policy among Services increases the difficulty in interconnecting. A common, DoD-wide policy could easily solve this self-inflicted impediment to interoperability. In addition, it is counterproductive to use one policy for exercises and experiments, and then have to adjust to another policy during real-world contingencies.

Commonality of systems. The ability to pass data directly between systems without having to rely on a translator, such as GCCS, greatly increases the speed and accuracy of the CROP. AFATDS, for example, increases the capability to interconnect between Services. Further development of message compatibility between MCS and IMACCS systems would better enable direct transfer of the tactical picture.

Web-based interoperability. Web-based systems, such as IWS, allow for interoperability of digital operations without requiring the traditional engineering nightmare of "interoperability of digits." This is especially useful for disparate software systems that do not provide common data types. For example, a Web-based system allows captured weather data dis-

played at all workstations without the need to load similar software and send detailed data fields.

Doctrine. Future joint doctrine should better define the relevant information for a CROP in support of a joint force commander, and standardize procedures to capture data from organic assets and echelons above and below. Everyone should have access to the database and the tools necessary to build the view of the battlespace they require.

Training. Training should focus across the levels of skill required to support the information technology that provides the CROP. This includes warfighters who operate the GCCS hardware and software, the track managers at all levels of command who conduct the critical correlation functions, and the database managers who ensure that the common tactical database includes timely and relevant data. The CROP managers, working with systems administrators, must manage the entire CROP system and ensure that it provides the commander with a tool that adds value to the decision-making process.

Collaborative planning tools such as IWS are easy to learn and use and very beneficial. The personnel utilizing IWS during this experiment were able to learn enough of the IWS capability to conduct collaborative planning sessions in less than one hour of training. As collaborative capability expands to other more common systems, this training requirement will disappear as collaborative planning with tools becomes intuitive.

Leader development. Leader development must grow current and future leaders who understand the advantages and limitations of a CROP. This training must include how a commander should shape a CROP based on different scenarios in the spectrum of conflict and his personal style of processing information and decision making.

Organizations. The future development of the CROP requires an examination into how adapting organizations might maximize this tool's potential. Potential examples:

- Reorganizing staffs around information instead of functions.
- Using technology with reach-back to reduce the core staff of a JTF and facilitate a more efficient decision cycle process.
- Adapting this capability to other areas, such as combat support and combat service support, to synchronize the tempo of operations.

Every commander should provide guidance to tailor the CROP based on his hierarchy of importance. From this commander's guidance, the CROP manager will have to continuously and aggressively manage both the tools that display the CROP and the information database that feeds the system. This management includes adjusting filter settings, correlating multiple

sources of tracks, and fusing the information that will enhance the relevance of the display. In addition, the commander must develop standing operating procedures (SOPs) that delineate the format of collaborative planning sessions. During these sessions, participants must look at the same picture with the same scale, time hack, and filter settings or a common picture of the battlespace will not exist. This management is a key to the effective and efficient use of the CROP for enhancing situational understanding of the battlespace and achieving decision superiority.

Acronyms and Abbreviations

4ID	4th Infantry Division
ABCS	Army Battle Command System
AFATDS	Advanced Field Artillery Tactical Data System
AGCSS	Army Global Command and Control System
AMDWS	Air and Missile Defense Warfare System
AOR	area of responsibility
ASAS	All Source Analysis System
ATCCS	Army Tactical Command and Control System
BCT	Brigade Combat Team
Bde	brigade
CA	California
CAS	close air support
CDR	commander
CINC	commander in chief
COL, Col	colonel
COP	Common Operational Picture
CONOPS	concept of operations
CROP	Common Relevant Operational Picture
CSSCS	Control Service Support Control System
CTD	Common Tactical Dataset
CTOC	Configurable Tactical Operations Center
CTP	Common Tactical Picture
CTSF	Central Technical Support Facility
DAMS	Digital Asset Management System
DoD	Department of Defense
DOTLMPF	Doctrine, Organization, Training, Leader Development, Materiel, People, and Facilities
ECOC	Experimental Combat Operations Center
FBCB2	Force XXI Battle Command Brigade and Below
GCCS	Global Command and Control System
GCCS-A	Global Command and Control System–Army

GCCS-M	Global Command and Control System–Maritime
GCE	Ground combat element
ID	infantry division
IDA	Institute for Defense Analyses
IMACCS	Integrated Multi-Agent Command and Control System
ISDN	Integrated Services Digital Network
ISR	intelligence, surveillance, reconnaissance
IWS	InfoWorkSpace
J-9	Joint Experimentation Directorate (US Joint Forces Command)
JAWP	Joint Advanced Warfighting Program
JFC	joint force commander
JFLCC	Joint Force Land Component Commander
JTF	joint task force
Kbps	kilobits per second
MAGTF	Marine Air-Ground Task Force
Maj	major
Mbps	Mega-bits per second
MCS	Combined Arms – Maneuver Control System
MEB	Marine Expeditionary Brigade
METOC	Meteorological and Oceanographic
MS	Mississippi
Mtn.	Mountain
SPMAGTF (X)	Special Marine Air-Ground Task Force (Experimental)
TADIL	Tactical Data Link
TCO	Tactical Combat Operations
TF	task force
TOC	Tactical Operations Center
TTPs	tactics, techniques, and procedures
TX	Texas
UAV	unmanned aerial vehicle
VTC	video-teleconferencing
U.S., US	United States
USA	US Army
USAF	US Air Force
USMC	US Marine Corps
USN	US Navay
VA	Virginia

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Rick Lynch, Tom O'Leary, Tom Clemons, Doug Henderson

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13. ABSTRACT (Maximum 200 words)

In 1999–2000, an ad hoc Interoperability Team, composed of individuals from two Services and Joint organizations, was formed to help develop and coordinate a series of joint experiments between the US Army and the US Marine Corps, the results of which were a first step towards facilitating Service interoperability and collaborative planning. The idea for forming the ad hoc Team came about because two active duty personnel recently assigned to the JAWP had served as commanders of the USA 1st Brigade of the 4th Infantry Division, the Army's experimental digital brigade at Fort Hood, Texas, and the USMC's Special Purpose Marine Air-Ground Task Force (Experimental), at Quantico, Virginia. Meeting and working together for the first time, the two colonels realized that their Services were both pursuing individual digital command and control experimentation; both organizations faced similar challenges; and many of the lessons learned were similar but there was no venue for the current commanders and their organizations to share common experiments.

The Interoperability Team ended up accomplishing more than a simple introduction and an exchange of "lessons learned." The Team defined and established an experimental common relevant operational picture (CROP) for an upcoming major event, the Millennium Challenge 2000. The joint experiments improved collaborative planning and promoted the sharing of digital tools and lessons learned. They also enhanced the training of leaders and staff in a joint, digital simulation and live environment.

14. SUBJECT TERMS
Joint experimentation, simulation, architecture, joint warfighting, common relevant operational picture (CROP), collaborative planning, digitalization, Global Command and Control (GCCS), Millennium Challenge 2000.

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